MODIS DATA SYSTEM STUDY

TEAM PRESENTATION

January 27, 1989

AGENDA

1. Data Requirements Document

2. Interface Document Between the MODIS Instrument and the MODIS Ground Data System: Planning and Scheduling; Control and Monitoring

3. Complexity and Scope of MODIS Metadata

4. Level-4 Processing Operations Concept

DATA REQUIREMENTS DOCUMENT

1. GENERAL INFORMATION

   1.1 Summary

   1.2 Environment

   1.3 References

   1.4 Modification of Data Requirements

2. INSTRUMENT, GEOPHYSICAL, AND ANCILLARY DATA

3. MESSAGES AND REPORTS

   3.1 Planning and Scheduling

   3.2 Control and Monitor

   3.3 Data Processing and Archival

ACCEPTED-DATA

1. DESCRIPTION:

Definition DADS ingested data that has been quality checked.

Purpose

Generation Process

2. PATH:

Source

Recipient

Medium

3. REQUIREMENTS:

Input Data

Quality

Timeliness

Completeness

Other

4. ATTRIBUTES:

Resolution and Coverage

Volume

Storage and Availability

Units, Scales, and Conversion Factors

Frequency of Update and Processing

5. IMPACTS:

ALGORITHM-RELEASE-ANNOUNCEMENT

1. DESCRIPTION:

Definition — Announcement to the team that a debugged, working processing algorithm is now in use, containing information such as version numbers, availability of user's guide, etc.

Purpose

Generation Process

2. PATH:

Source

Recipient

Medium

3. REQUIREMENTS:

Input Data

Quality

Timeliness

Completeness

Other

4. ATTRIBUTES:

Resolution and Coverage

Volume

Storage and Availability

Units, Scales, and Conversion Factors

Frequency of Update and Processing

5. IMPACTS:

INTERFACE DOCUMENT BETWEEN THE MODIS INSTRUMENT
AND THE MODIS GROUND DATA SYSTEM:
PLANNING AND SCHEDULING AND CONTROL AND MONITORING

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COMPLEXITY AND SCOPE OF MODIS METADATA

MODIS Metadata issues are in part derived from projected MODIS data usage and data granularity. The metadata's depth and breadth has an effect on the level of processing necessary for the MODIS datasets' production, the amount of storage necessary for these datasets, and the Science user's ability to retrieve these datasets. In order to determine the most effective way to apply and utilize metadata, MODIS metadata issues will be addressed through questions such as:

1. What is the lowest level of MODIS data that could be individually addressable?

2. What effects do alternative levels of MODIS data granularity have on the quantity or quality of metadata?

3. Are trade-offs involved in including some MODIS non-science data as metadata, vis a vis maintaining separate databases for science and non-science data?

4. To what degree could MODIS data usage level be an indicator of metadata needs?

5. Do MODIS standing orders have impacts on metadata requirements?

LEVEL-4 PROCESSING OPERATIONS CONCEPT

I. Level-4 Product Definition

II. Input Data Requirements

III. Data Processing Requirements

IV. Generic Level-4 Processing Scenarios

I Level-4 Product Definition

Level-4 products consist of model output and scientific validation analysis of lower level data. Level-4 processing differs from the lower-level processing in the variety and complexity of possible scenarios ranging from routine comparisons of lower level MODIS products with correlative data to the use of MODIS data (perhaps along with other Eos and non-Eos data) in geophysical models to produce products such as water balance dynamics, weather and climate forecasts, vegetation phenology, global biological productivity, etc. Level-4 products are either standard or special. A standard Level-4 product regardless of complexity or volume of the required input data set would be produced at the CDHF in the same way as all of the lower level products. Special Level-4 products would be produced on TMCF processing facilities. A precise definition of a Level-4 product is not possible because of the large range of Level-4 products. We have illustrated this in Figure 1 by showing how some specific Level-4 products overlap the following categories: Level 1-3, Level-4, and general scientific applications. Figure 1 shows the range of possible MODIS Level-4 products, and illustrates the overlap of MODIS Level-4 with lower level MODIS products and general scientific applications. The following "strawman" assumptions are made here regarding the classification of data as MODIS Level-4 products. All data products produced on EosDIS unique computing facilities with MODIS data products as the major input data and using algorithms approved by the MODIS science team, are assumed to be MODIS data products. As stated above, Level-4 data products may be the results of analysis of lower level data (Levels 1, 2, or 3) using geophysical models. Level-4 data will often be gridded, time averaged or composited, and, therefore, may resemble Level-3 products. Figure 1 illustrates the overlap or uncertainty between Level-4 and lower level products. On the other side of the figure, the overlap or uncertainty between Level-4 products and general scientific applications is shown. At this point, scientific applications of lower level MODIS data products, which are performed on EosDIS supported facilities and approved by the MODIS science team, will be considered as Level-4 products.

II Input Data Requirements

A Level-4 product may draw on many sources for input data. This input data may be lower level MODIS data, other Eos instrument data, non-Eos instrument data, non-Eos archive data, as well as other correlative data. Lower level MODIS data will be the easiest resource for the MODIS researcher to access. The synergistic nature of the Eos project instruments will make the integration of non-MODIS instrument data sets necessary. Non-Eos instrument data and non-Eos archive data, although more difficult to handle than Eos data, will be needed in performing validation studies and trend analysis of Eos data products.

III Data Processing Requirements

The scheduling of Level-4 production will be highly dependent upon the requirements of specific products. This processing schedule may be daily, weekly, monthly, or only yearly. For example, daily production would be required to produce 6-hour global forecasts, alternatively, a global vegetation index phenology (analysis of the cycles of the growing season) would be performed only once each year. Since standard Level-4 products for global modeling and validation analysis may have only weekly, monthly, or even yearly production demands, and large processing demands and data sets, it is possible that standard Level-4 products would have a separate processor at the CDHF. Such a separation would help avoid any processing time conflicts between the daily production of standard products and the variable demand of Level-4 products. Data handling of Eos information and implementation into Level-4 production should be as straightforward as for Levels 2-3 processing. Non-Eos data location and differences in data format could make the production of some Level-4 products cumbersome. The storage requirements for Level-4 products at this time are TBD because the list of specific Level-4 products are not well-defined. These requirements must be satisfied by the DADS and the permanent archives.

Much of Level-4 analysis requires mapping of MODIS data. For this purpose, it is envisioned that graphics and mapping (including color) packages would be available via workstations at the TMCF or CDHF. To be an Eos product, a Level-4 product would be produced on Eos-funded computing facilities. If processing was performed at the CDHF, the product would be a standard Level-4 product. The data handling requirements depend entirely on the particular Level-4 product. The most complicated case is a Level-4 product that would be produced daily and require that many different sources of non-Eos input data be combined with MODIS data.

IV Generic Level-4 Processing Scenarios

At this point, very few Level-4 data products have been clearly defined. In this section, generic Level-4 examples along with specific examples are presented.

A. Results of comparisons of MODIS data products with correlative data.

The correlative type of Level-4 products derived by comparison of MODIS data products with non-MODIS or non-EOS correlative data will be performed on the CDHF or TMCF computers. Lower level MODIS data and the correlative data are the only required inputs. The processing may consist of resampling and/or reformatting both MODIS and correlative data to permit the analysis (e.g., statistical) of the differences between the two data sets. Output Level-4 products produced in this manner could be maps or tables of difference fields and other statistics of the comparison.

1. Validation of Sea Surface Temperature Retrievals

Many MODIS data products will need to be validated against ground truth data. For example, MODIS derived sea surface temperature would be compared with coincident in situ measurements. The output of this analysis could consist of scatter plots of the retrieved versus in situ SST measurements, maps of the differences between MODIS and correlative in situ data, and other statistics of the comparison. A scenario for this analysis is shown in Figure 2.

B. Results of using MODIS data as inputs to geophysical models.

Geophysical models may be used to derive other parameters from MODIS data. This model analysis could be done at the CDHF as well as on TMCF computing facilities. A combination of Level 1, 2, or 3 MODIS data, non-MODIS instrument data, and conventional data would be input to the geophysical model. It may be necessary to reformat or resample this data to conform with a particular model grid space. This data may be used to initialize a predictive-type model (e.g. a global circulation model). The Level-4 product could be fields of predicted parameters or simply maps of a derived product.

1. Global Forecast Model

Currently, a 6-hour forecast is derived from satellite retrieved data and conventional measurements using a global forecast model. The satellite-retrieved data consists of atmospheric temperature and moisture profiles, and surface temperature derived from HIRS2 and MSU measurements. These soundings are used to initialize the general circulation model. For Eos, a combination of AIRS, AMSU, and MODIS data would be required. Conventional measurements would be obtained from non-Eos data sources. It may be necessary to produce such a forecast in near-real time. For example, HIRS2/MSU was used to provide completely analyzed fields of satellite data to support the Antarctic ozone hole experiment in 1987.

2. Ocean Carbon Flux

One of the goals of the Earth Observing System is to put together a complete picture of the earth's carbon cycle. An important link in this cycle that can be examined using MODIS data is the ocean-atmosphere exchange of carbon dioxide. The carbon dioxide uptake by the ocean is determined by oceanic circulation, sea-surface temperature, ocean surface windstress (or surface roughness) and biotic activity. Sea-surface temperature and biotic activity would be derived primarily from MODIS measurements. The Scatterometer (SCATT) will be used to measure windstress over the ocean. These satellite-derived parameters would be combined in a model to calculate the ocean carbon dioxide uptake. A scenario in which this parameter is produced at the TMCF is shown in Figure 3.

3. Land Surface Water Budget

The object of this study is to estimate continental water balances for time scales ranging from days to seasons to decades.

By using remotely-sensed as well as conventional data, investigators hope to develop more physically complete descriptions of the components of the land water balance. MODIS data as well as data from other Eos instruments will be required to derive surface albedo, vegetation, surface temperature, precipitation, and snow areal cover. These parameters will be used in several models. Some examples of these models are a seasonal water balance model of natural grasslands and forests, a model relating seasonal evaporation to vegetation growth, a daily evaporation estimation model based on surface energy balances, and a boundary layer model. The nominal output data product would be daily evaporation estimates and monthly water balance estimates for continental areas at a resolution of 20 km.

C. Results of analyzing time series of MODIS data to detect trends or to understand geophysical phenomena.

The trend analysis standard MODIS data products along with long time series studies of global processes will be an integral part of the Level-4 product group. The projected extended mission lifetime of the MODIS instrument and the entire platform will provide data sets of global coverage of many frequencies for fifteen years. This data collection will be the foundation for the intricate studies of global scale processes and interactions.

A trend analyses of standard MODIS data products will be performed to determine instrument health as well as the long term behavior of derived parameters under study. This analysis would most likely be performed at the TMCF. Possible specific purposes of this type of analysis are to understand instrument behavior (e.g. instrument degradation), to detect real geophysical trends, or to gain an understanding of natural geophysical processes (e.g. an El Nino type of climatological event). The selected MODIS data products will be retrieved from the DADS and permanent archives in a systematic manner for analysis. In order to understand long term performance, comparisons will be made with ground truth and ancillary data in addition to relevant Eos and non-Eos instrument data sets. A team member will have the freedom to review and combine years of data from numerous instruments providing global coverage to validate intricate long and short term global process models.

1. Vegetation Index Phenology

One of the vegetation index products is a 10-day global composite vegetation map. Each year's growing season is summarized by a set of these maps. The vegetation index time series for each pixel is analyzed to estimate the duration and timing of the growing season. The results of this phenology analysis would become a Level-4 product, which is only produced yearly.

2. Ozone Trend Analysis

One of the most important climatic changes to be investigated in recent years is the global scale decrease in ozone and the striking decrease in springtime Antarctic ozone during the last decade. Given the political importance of this issue, these changes will continue to be studied using Eos instruments (MODIS,GOMR). Current analysis of ozone trends has employed both ground-based (Dobson instrument network) and satellite instrument (Nimbus-7 SBUV, TOMS, and SAGE I and II) measurements of ozone. Comparisons between coincident ground-based and satellite ozone measurements are necessary to remove instrument effects from computed trends to obtain real climatological trends. A scenario for ozone trend analysis is given in Figure 4.

D. Results of analysis of the spatial gradient of MODIS data to understand geophysical phenomena.

Spatial gradients of a particular MODIS data parameter would be determined so that the physical horizontal transport associated with this parameter can be found. The input data for such a Level-4 product would most likely be a Level-3 or possibly another Level-4 product. One would compute the temporal change of the spatial gradient of a particular parameter by calculating the differences between maps for sequential time spans. From these difference maps, one would determine the net horizontal transport associated with the parameter. For example, the difference between consecutive global 10-day average maps of water vapor would be used to find the net transport of water vapor. Alternatively, a more complicated analysis requiring interaction with atmospheric and ocean circulation models may be necessary to determine equator to pole energy transport.

E. Other Candidate Level-4 Examples

1. Bi-directional models derived from MODIS data
2. Wind speeds from clouds at cloud top height and at surface
3. Ocean speeds from surface tracers
4. Deforestation rates per unit area
5. Relationship between ecological zone classification and surface temperature and precipitation
6. Radiative transfer models vs. MODIS measured radiances
7. Mesoscale model predictions vs. observed mesoscale variations
8. Teleconnection studies

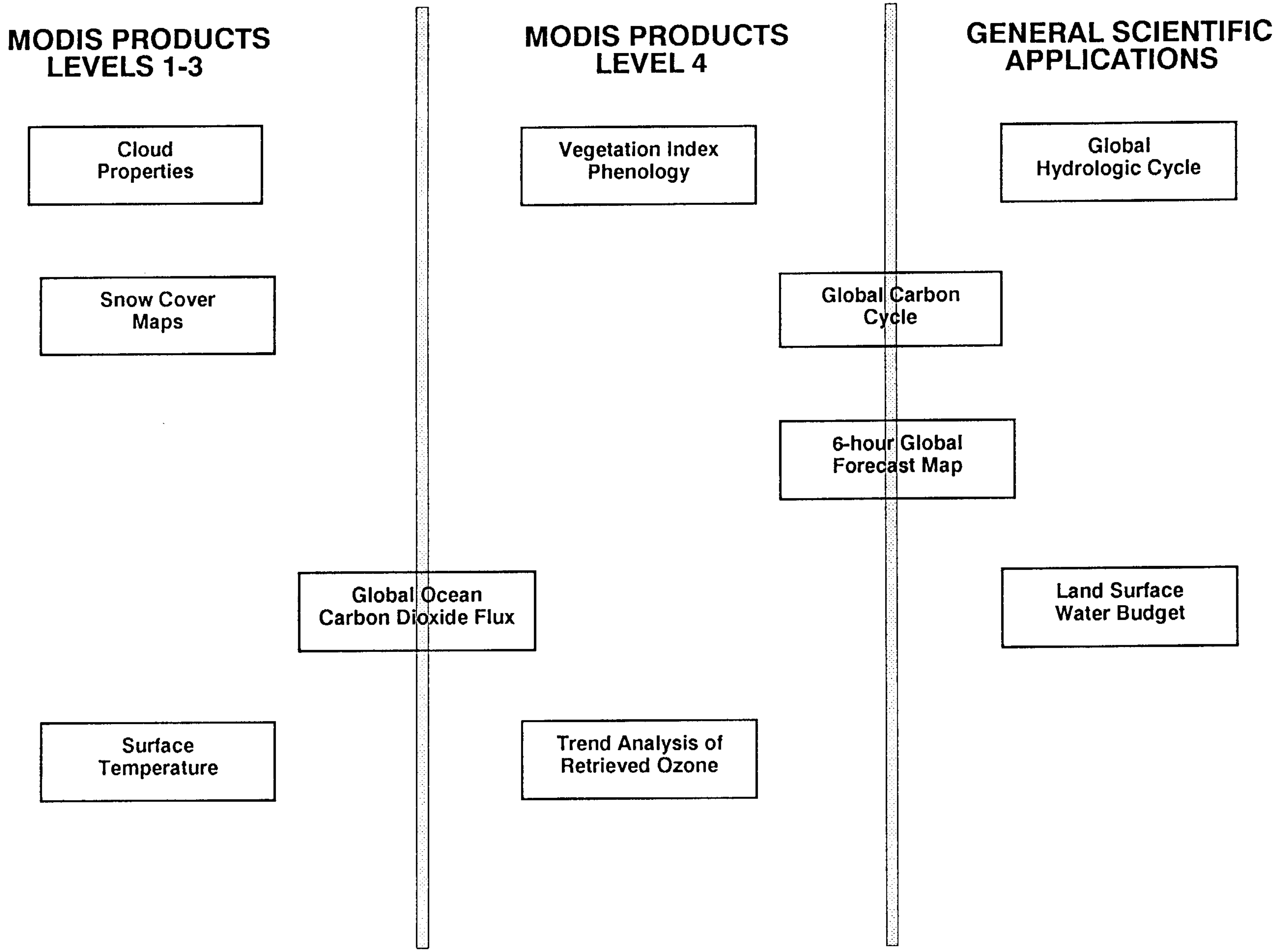
MODIS PRODUCTS
LEVELS 1-3
MODIS PRODUCTS
LEVEL 4
GENERAL SCIENTIFIC
APPLICATIONS
Cloud
Properties
Vegetation Index
Phenology
Global
Hydrologic Cycle
Global Carbon
Cycle
Snow Cover
Maps
6-hour Global
Forecast Map
Global Ocean
Carbon Dioxide Flux
Land Surface
Water Budget
Surface
Temperature
Trend Analysis of
Retrieved Ozone

FIGURE 1.

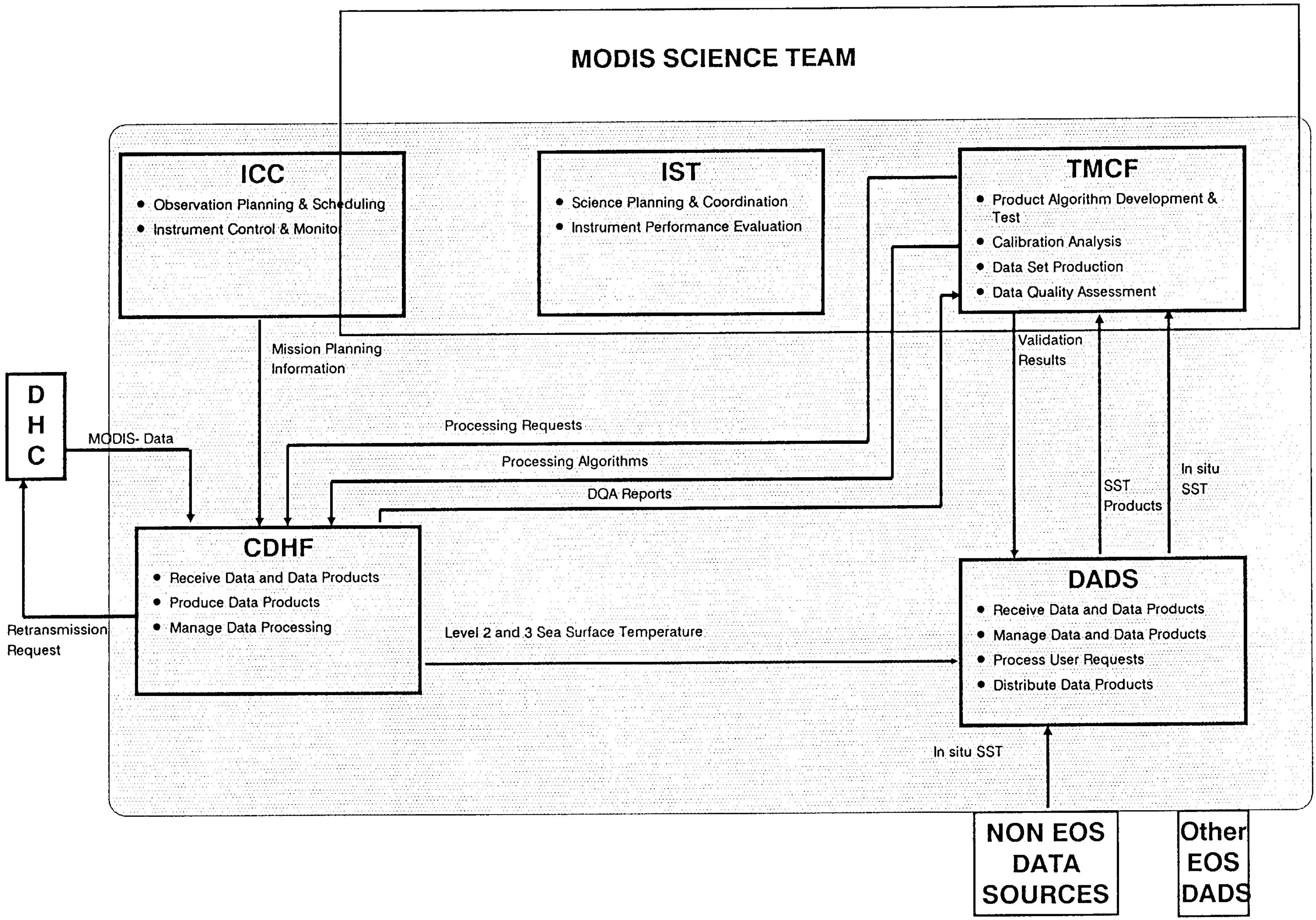

FIGURE 2. LEVEL-4 MIDACS SCENARIO FOR SEA SURFACE TEMPERATURE VALIDATION

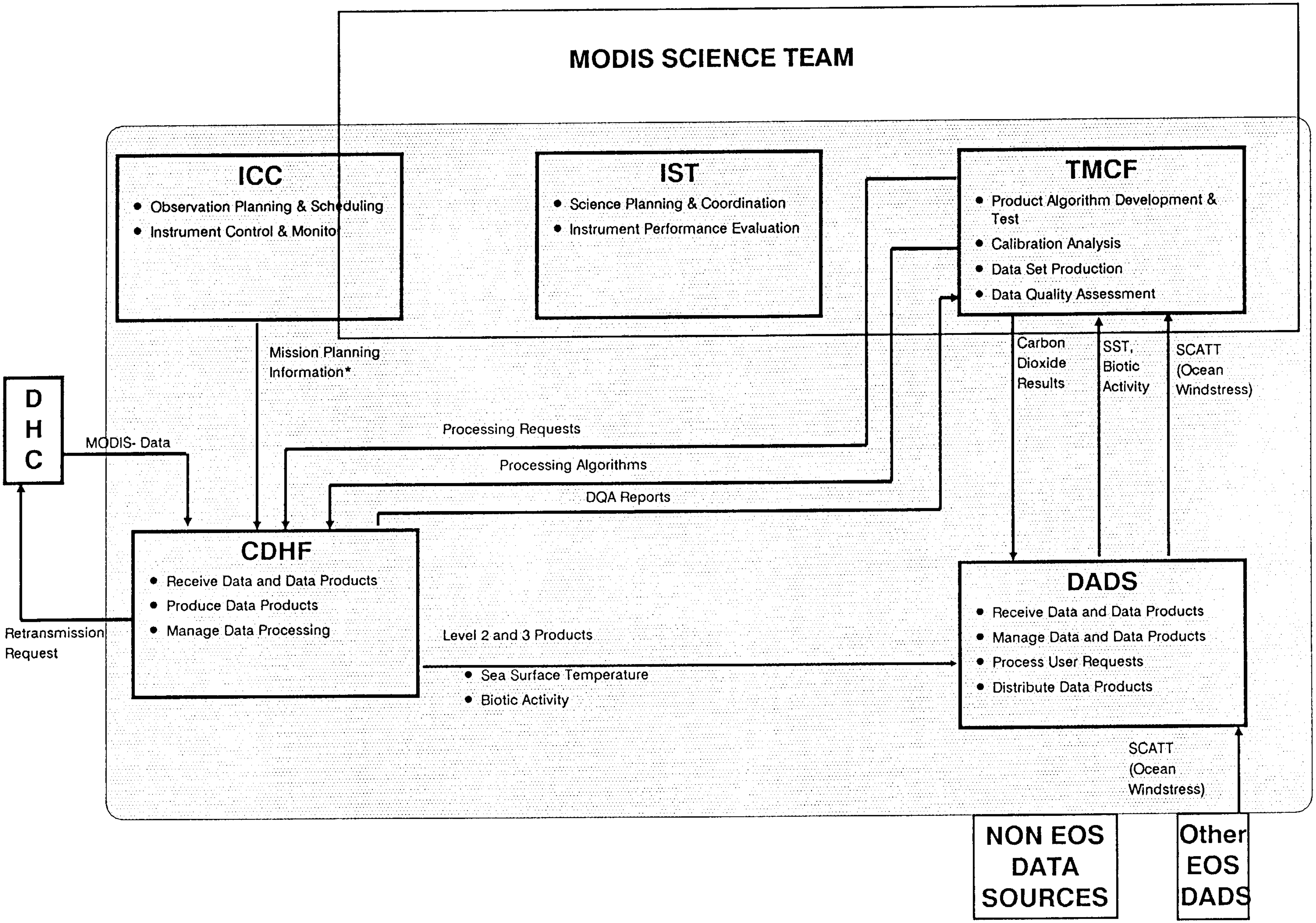

FIGURE 3. LEVEL-4 MIDACS SCENARIO FOR OCEANIC CARBON DIOXIDE EXCHANGE

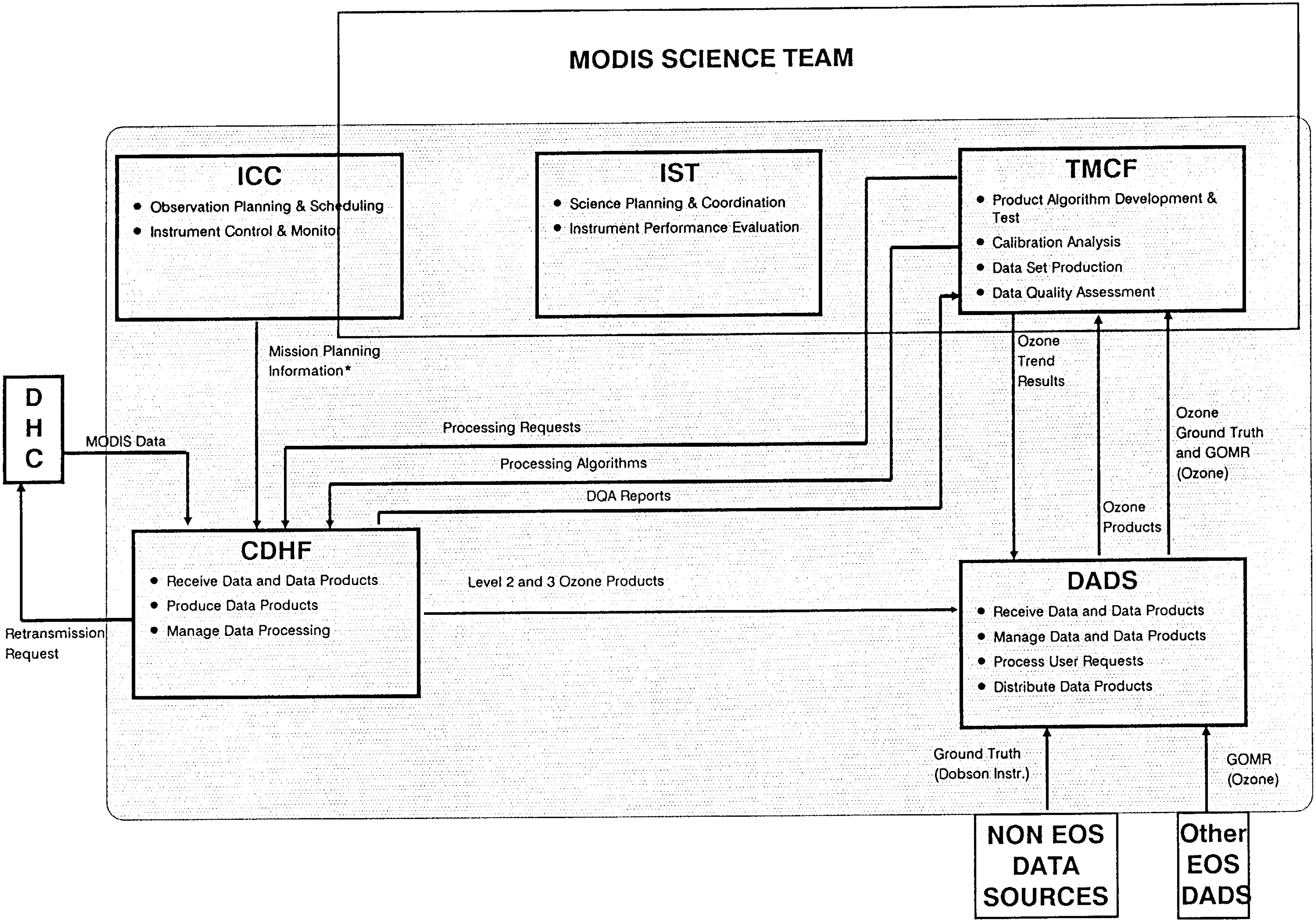

FIGURE 4. LEVEL-4 MIDACS SCENARIO FOR OZONE TRENDS